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Broken leads with proximal endings in the cardiovascular system: Serious consequences and extraction difficulties

Andrzej Kutarski[1], Barbara Małecka[2], Andrzej Ząbek[3], Radosław Pietura[4]

[1]Department of Cardiology, Medical University of Lublin, Lublin, Poland
[2]Department of Electrocardiology, John Paul II Hospital in Cracow, Cracow, Poland
[3]Department of Interventional Radiology and Neuroradiology, Medical University of Lublin, Lublin, Poland

Abstract

Background: *Retrospective analysis of effectiveness, technical problems, and complications of transvenous extraction of leads with the free endings migrated to the cardiovascular system (CVS).*

Methods: *A 5-year-old database of transvenous lead extraction (TLE) procedures comprising 906 patients with 1563 leads being removed was analyzed. TLE procedures of leads migrated in the CVS were compared with TLE procedures of leads with their proximal ends accessible in the pacemaker/implantable cardioverter-defibrillator (PM/ICD) pocket.*

Results: *In our material, the phenomenon of leads migration occurred in 5% of patients referred for TLE and affected most frequently unipolar and atrial leads. The presence of migrating leads was associated with local venous occlusion in 64% of patients. Removal of migrating leads required other techniques than extraction of leads with their proximal ends accessible in the PM/ICD pocket. More than 95% of migrating leads were extracted transvenously, but procedures were significantly longer. The presence of other leads made extraction of migrated leads even more complicated. Effectiveness and complication rates for removal of migrated leads and leads accessible in the PM/ICD pocket were similar.*

Conclusions: *We postulate that every lead migrating in the CVS should be considered for TLE. However, this extraction is technically more difficult and challenging than extraction of leads accessible in the PM/ICD pocket.* (Cardiol J 2013; 20, 2: 161–169)

Key words: pacing complication, broken leads, extraction of migrating leads, venous occlusion

Introduction

There is a growing number of patients with abandoned endocardial leads. The decision to abandon inactive lead is made in case of pacing and/or sensing abnormalities, or changing and upgrading the pacing system. An abandoned, cut short, and not sufficiently fixed lead creates the risk of migration into the cardiovascular system (CVS) [1]. Active endocardial leads also may migrate to the CVS after their breakage. This may occur as a result of crush syndrome in case of an unfavorable position of a lead and the clavicle [2]. There also is a risk of lead fracture and later breakage at the site of ligature tightening on the lead at the venous entrance. The migration of the proximal lead end (PLE) to the subclavian, anonymous vein, or superior vena cava creates loops, which in turn move through the

Address for correspondence: Barbara Małecka, MD, PhD, Department of Electrocardiology, John Paul II Hospital in Cracow, ul. Prądnicka 80, 31–202 Kraków, Poland, tel: +48 12 614 22 77, fax: +48 12 633 23 99, e-mail: barbara_malecka@go2.pl

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tricuspid valve to the right ventricle (RV), provoking tricuspid valve dysfunction and ventricular arrhythmias [1].

Sometimes, the free PLE drops in the right heart cavities or pulmonary artery, causing pulmonary embolism [1]. Practically, every lead, the free ending of which is dropped in the CVS becomes a potential source of the above-mentioned consequences and is class 1 (lead with ending in CVS, which may pose an immediate threat to the patient if left in place, life threatening arrhythmias secondary to retained lead or lead fragment) or class 2b indication (lead which may pose a potential future threat to the patient if left in place) according to the latest guidelines of the Heart Rhythm Society (HRS) [3].

A number of centers have described their experience in transvenous lead extraction (TLE), presenting encouraging results of low percentage of complications [4–6]. There are no descriptions of TLE procedures with free PLE migrated to the CVS, based on a larger population of patients with such a problem, except a few case reports [4, 7–10].

The aim of our study was to analyze the effectiveness, technical problems, and complications of TLE with PLE migrated to the CVS. An additional goal was to analyze after-effects and symptoms of long dwell times of PLE in the CVS and to present our original techniques of TLE with PLE in the CVS.

Methods

A retrospective analysis of a 5 year-old database of TLE procedures comprising 906 patients with 1563 leads being extracted was carried out. The main database inclusion criterion was the dwell time of leads in the CVS. For pacemaker (PM) leads, it was > 12 months, and for implantable cardioverter-defibrillator (ICD) leads, > 6 months. Another inclusion criterion with shorter dwell times was the need to use additional tools, not provided with the lead by the manufacturer, because of ineffective simple traction. TLE procedures of leads with PLE migrated to the CVS were compared with TLE procedures of leads with their proximal endings accessible in the PM/ICD pocket. For this reason, patients were enrolled in two arms of the study. One arm — Group A comprised patients with at least one lead, the PLE of which migrated to the CVS, and the other arm — Group B included the remaining patients. The following parameters were compared: (1). Patients' age and gender; (2) Indications for extraction in three groups: lead-dependent infective endocarditis (LDIE), local pocket infection, other noninfectious indications; (3) Number of existing and removed leads per patient; (4) Extracted lead dwell times; (5) Technique of TLE; (6) Procedure effectiveness understood as complete removal of all planned leads; (7) A technical complication was regarded as an appearance of a new technical problem during TLE, which had to be solved, prolonging the duration of procedures. The following technical complications were encountered: subclavian vein entry block (metal sheath or another technique was used), lead fragmentation (extraction in two parts), lead breakage (lead fragment extraction), loss of liberated distal lead fragment (additional removal of lead fragment from the CVS), strong lead-to-lead adhesion (simultaneous liberation with two dilators), functional lead dislodgement, and Byrd dilator fracture (only replacement); (8) Procedure complications (minor and major) and radiological success defined according to the HRS guidelines [3]. Based on the data, we analyzed probable reasons for PLE migration to the CVS. The site and mechanism of lead breakage can be diagnosed only when, during reimplantation, the proximal fragment of the lead connected to the device in the poket is removed. Additionally, we analyzed the final migration site of the PLE as well as the incidence of total or partial venous occlusion in the PLE site in the subgroup of patients with migrating leads. For the latter reason, prior to TLE, we performed venography with intravenous contrast medium in the cubital fossa on the side of the PM/ICD pocket in those patients (Fig. 1).

TLE procedures were performed after patient's written informed consent form for the operation and also consent use his medical records anonymously for research purposes.

Description of lead extraction methods

Leads accessible from the PM/ICD pocket were described before [11].

Procedure 1. TLE with ends migrated to the CVS when PLE was not strongly ingrown into the wall of the CVS (Fig. 2). Such leads were usually extracted via a femoral vein. The access to CVS was obtained using Cook Femoral Work Station® (FWS) or Medtronic Attain CS set® or Biotronik Scout CS set® designed for left ventricular lead implantation. A "pigtail" catheter was introduced additionally to the use of the above-mentioned sets and wound around the lead under removal, maneuvering the liberated PLE to the vena cava inferior. At this moment, extraction with the femoral approach was continued most frequently. The PLE was grasped with a Basket Dotter® or lasso catheter, and simple traction or countertraction (internal sheath of

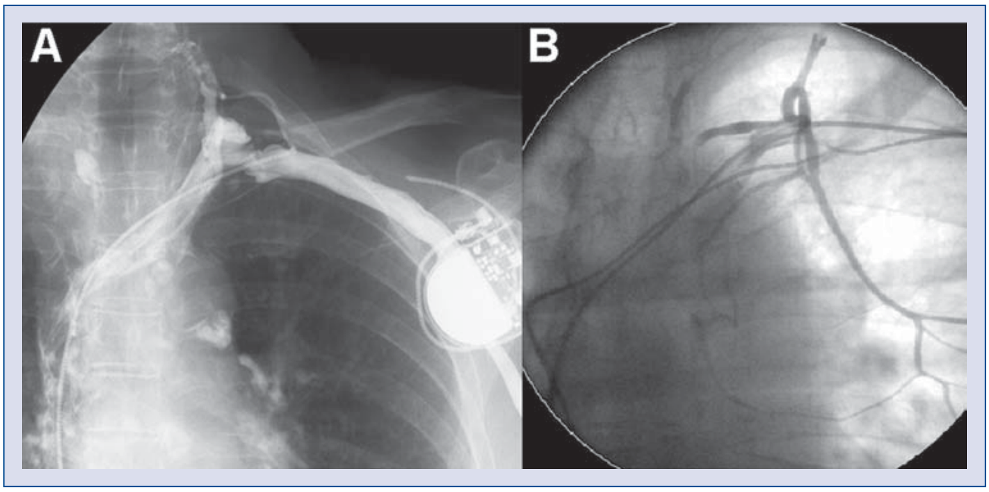

Figure 1. Intraoperative fluoroscopy during venography visualizing veins with the migrating leads; **A.** Mild occlusion of the left subclavian vein; **B.** Significant occlusion of the left subclavian vein — collaterals.

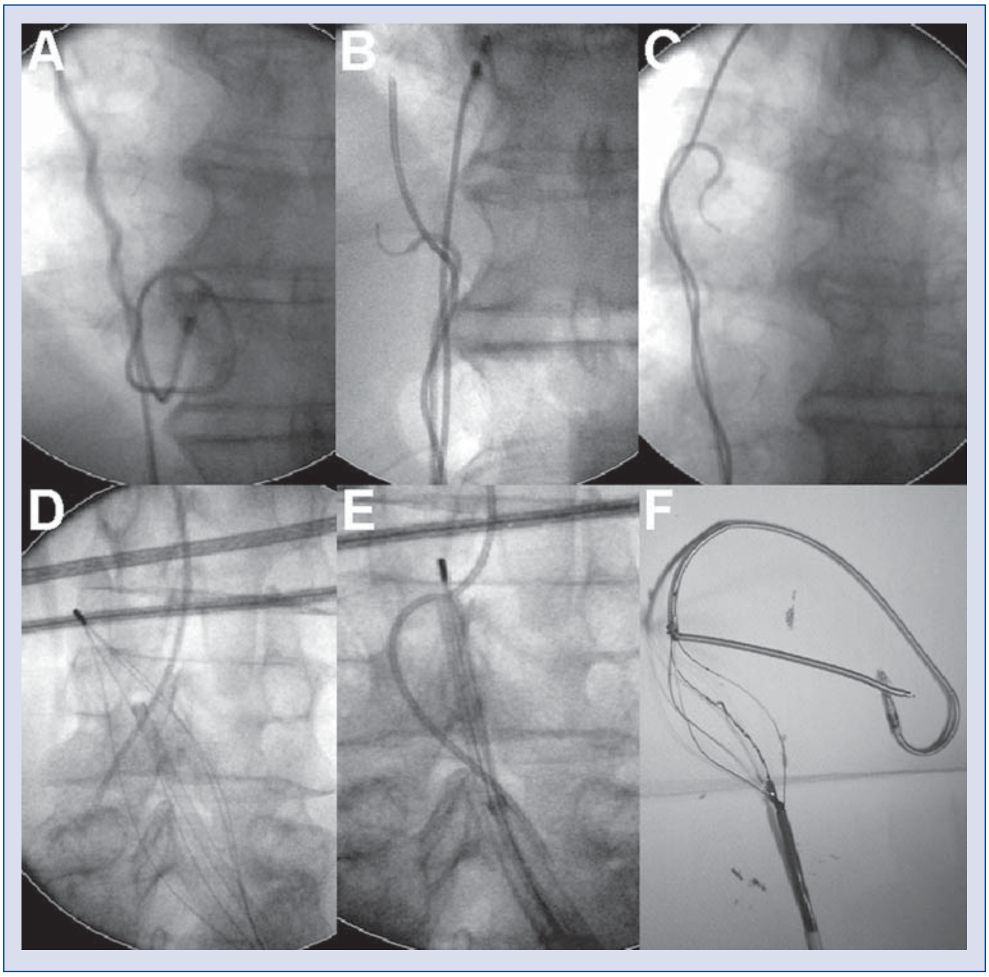

Figure 2. Intraoperative fluoroscopy during removal of the migrating lead (procedure 1); **A.** The pigtail catheter wound around the lead in the right atrium; **B.** Freeing the proximal end of the lead; **C.** Lead proximal end in vena cava inferior with pigtail wound around it; **D.** Dotters basket grasping the proximal tip in the vena cava inferior; **E.** Dotters basket closed, enabling firm traction of the lead via the femoral approach; **F.** Extracted migrating lead on the table with Dotters basket.

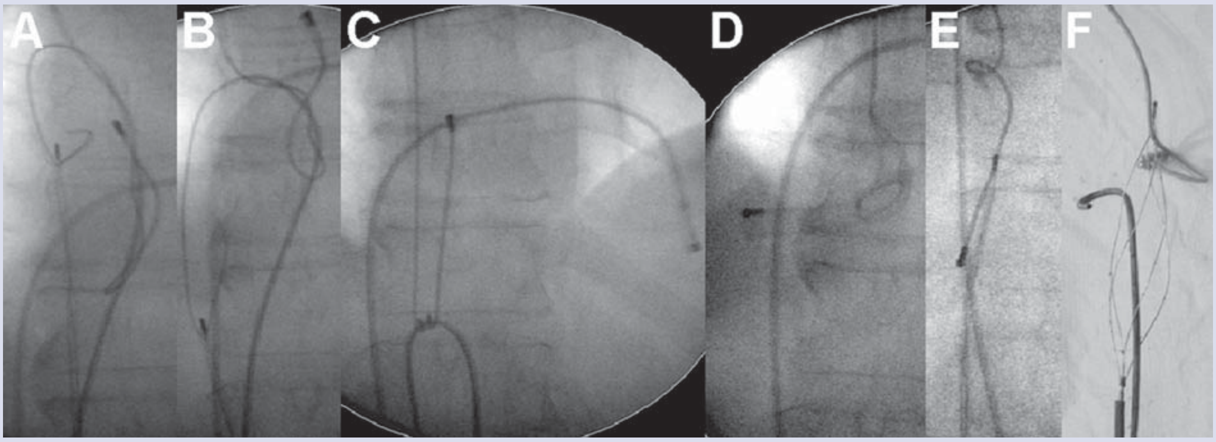

Figure 3. Intraoperative fluoroscopy during freeing the two adherent endings of the migrating lead (procedure 2); **A.** A strong angiocardiographic guidewire, inside the pigtail, passing through the lead loop in the right atrium; **B.** Distal part of the angiocardiographic guidewire grasped by a Dotter basket; **C.** Manual traction simultaneously applied to the two ends of the loop formed by the guidewire; **D.** Liberated distal lead tip; **E.** Dotters basket grasping the tip in the vena cava inferior; **F.** Dotters basket, pigtail catheter and extracted lead on the table.

FWS) was attempted. These maneuvers sometimes were sufficient to liberate the lead with its tip off the adhesions in the heart walls. If the distal part of the lead very strongly adhered to the surrounding tissue scar, there was a need for separation using extra-long polypropylene Byrd dilators or manually modified external or internal FWS sheaths. The manual modification was carried out by cutting the edges of the catheters diagonally, which broadened their function from countertraction to rotation--cutting as well. Cutting off lead adhesions with the help of manually modified FWS is more effective and safer than applying only countertraction force which can tear CVS walls. However, manufactures of FWS have not anticipated the need of cutting of migrating lead adhesions. For that reason manual modification of the FWS ending during such procedures is necessary.

Procedure 2. TLE with ends migrated to the CVS when PLE was strongly ingrown into the wall of the CVS (Fig. 3). In the case of strong adhesion of both lead ends to the CVS, the authors employed their original method, that is, the extracted lead with strongly ingrown endings was looped by the strong angiocardiographic guidewire introduced via the pigtail catheter, and the distal part of the angiocardiographic guidewire was grasped by a Basket Dotter® or lasso catheter (both tools were similarly useful). Either mentioned tool was introduced via the same femoral vein but via a separate approach and inside a larger sheath (FWS, Medtronic Attain CS set® or Biotronik Scout CS set®). Manual traction applied to the guidewire and simultaneously to the basket/lasso catheter liberated one of the extracted lead endings (usually, the proximal one but not always). The liberated extracted lead end was grasped using Basket Dotter® or lasso catheter, whereas rotation of the catheter (obliquely cut FWS sheath or Byrd dilator) was used to liberate the remaining ending. If the distal ingrown lead tip was located in the RV apex and the angulation in the tricuspid valve region was too sharp, we used the superior approach (recaptured subclavian approach or jugular approach) to intercept the previously liberated lead ending with another Basket Dotter® or lasso catheter.

Sporadically, an approach from the internal jugular or subclavian vein opposite to the PM/ICD pocket was used. We developed our own technique, which permits to draw Byrd dilators over these tools [8].

Ingrowing of the migrating PLE into the CVS walls was not determined before choosing the extraction approach. We used a stepped-up approach: first trying with a pigtail catheter to free the proximal (or distal end) — procedure 1, and if the pigtail did not suffice, then we snared the lead to free one or the other end with traction — procedure 2. After one end of the lead was freed, we first tried to extract the lead with traction, or if it was not successful, by inserting a sheath over the lead to free it from scar tissue.

If the access technique was modified during the procedure, it was referred to as a complex pro-

Table 1. Migrating lead models; comparison with the control group.

		Group A	Group B	P
Number of leads (only migrating leads in group A)		45	1478	–
Location of the tip of the lead	A	27/45 60.00%	655/1478 44.32%	0.0371
	V	18/45 40.00%	823/1478 55.68%	
Lead model (polarity)	BP	26/45 57.78%	1332/1478 90.12%	< 0.00001
	UP	19/45 42.22%	146/1478 9.88%	

cedure. In the cases of infectious indications when all existing endocardial leads were removed, the procedures began from TLE of leads accessible in the pocket, whereas for noninfectious indications, only migrated or redundant leads were planned to be extracted. In the case when venous occlusion prevented the implanting of the new leads by subclavian venipuncture, the patient had to undergo removal of the lead accessible in the pocket to regain venous access from pocket site. The migrating lead was extracted at the same time.

All removal procedures were performed under light general anesthesia (propofol) in an operating room with cardiac surgery, anesthesiology backup, and monitoring of patients' vital signs.

Statistical analysis

Statistical analysis was carried out using Statistica version 9.1 (Stat Soft). Minimum and maximum values, means, and standard deviations were calculated for continuous variables, whereas qualitative variables were presented as absolute and percentage quantities. The Shapiro-Wilk test for normality was used to analyze continuous outcome variables. Unpaired Student's t-test was used to compare two quantitative variables, and when the data sets were skewed or scanty, a non-parametric Mann-Whitney U-test was performed. Pearson's χ^2 test was used to compare qualitative variables, whereas Yates's χ^2 test was used for small samples (less than 5 subjects). A p value < 0.05 was considered statistically significant.

Results

Group A with the migrating PLE consisted of 45 patients. Of the 45 removed migrating leads in these 45 patients, 40 leads with PLE accessible in the PM/ICD pocket were extracted. These 45 patients made up 5% of the 906 patients. The remaining 861 patients served as the control group (B) with 1478 leads having been extracted.

Characteristics of migrating extracted leads. The phenomenon of PLE migration into the CVS seems to be most typical of atrial, unipolar leads (Table 1).

Final migration site of the PLE of 45 migrating leads. The PLE was anchored in the subclavian vein, 19 cases; in the innominate vein (12), in the right atrium (4), in the pulmonary artery (3), in the vena cava superior (2), in the jugular vein (2); in the right ventricle (2), and in the hepatic vein (1).

Probable reasons of lead migration to the CVS. In 24 patients, in the previously functional lead, after its breakage, the PLE slid into the CVS, which manifested in 16 patients as sudden loss of pacing/sensing. The patients received new leads in other centers.

The proximal end of the lead connected to the device in the pocket was removed in our center in 8 cases. In this way, in 5 patients, crush syndrome was detected, and in another 3 patients, complete lead breakage was caused by too tight ligature on the distal edge of the anchoring sleeve.

In another 21 patients, the migrating leads were previously abandoned and inactive. The probable reason of migration was abandoned PLE ligature failure. However, in 5 patients, the lead was attempted to be extracted by manual traction in other centers, and if it was ineffective, the lead was cut in the venous entrance region without ligature.

Time of PLE adhesion to CVS walls is difficult to specify even in the case of 16 patients with sud-

Table 2. Demographic data, indications for transvenous lead extraction (TLE), complexity of the system measured by the number of leads in the heart and the number of extracted leads in a single patient.

		Group A	Group B	P
Number of patients [%]		45/906 [5.0]	861/906 [95.0]	–
Number of extracted leads		85	1478	–
Gender: males [%]		26/45 [57.8]	635/861 [73.7]	0.0187
Patients' age [years] (SD)		12–88 64.7 (18.4)	5–94 64.7 (16.2)	0.6024
Number of leads in patient before TLE procedure (SD)		1–4 2.56 (0.87)	1–5 2.00 (0.83)	< 0.0001
Number of leads extracted in a single patient (SD)		1–4 2.02 (1.45)	1–6 1.73 (0.83)	0.0030
Mean dwell time of leads [months] (SD) (only for migrating leads in group A)		76–276 122.2 (62.8)	7–386 80.9 (60.2)	< 0.00001
Indications for TLE	LDIE [%]	8/45 [17.8]	168/861 [19.5]	0.7744
	Pocket infection [%]	7/45 [15.6]	237/861 [27.5]	0.0776
	Non-infective indications [%]	30/45 [66.7]	456/861 [53.0]	0.0723

den loss of pacing/sensing and 5 patients with intentional consent for PLE migration to CVS lumen.

Main reasons for referring the patient with migrating leads for TLE. Eight patients had LDIE, 7 had local pocket infection, and as many as 30 (66.7%) presented different noninfectious indications: migrating leads recognized as leads which may pose a potential future threat to the patient if left in place (27 patients), intolerance of VVI mode of pacing after atrial lead breakage (8 patients), another lead failure (7 patients), venous occlusion precluding additional lead implantation (12 patients), and symptoms of superior vena cava syndrome (3 patients). Most patients were referred when elective PM/ICD unit replacement was indicated. There were not significant differences in indications for TLE in both groups of patients (Table 2).

Migrating lead extraction methods. The complexity of PM/ICD systems and lead dwell times were significantly higher in patients with migrating leads (Table 2). The presence of other leads hampered the extraction of the migrating leads. Therefore, in 15 patients with infectious indications for TLE, the leads accessible from the PM/ICD pocket were removed first. In the remaining 30 patients with noninfectious indications, active leads were left in place. However, the active lead was dislodged accidentally in 3 patients, and for this reason, it had to be reimplanted at a later stage of the procedure. In one patient 2 year-old, still functional leads had to be extracted to enable the removal of the migrating lead. In 12 patients with a needed implantation of new leads by regaining access to the heart, this procedure was made after migrating lead extraction. If we analyze TLE of migrating leads only, it is clear that the femoral approach was used most frequently (in 66.7%) and combined (usually femoral plus recaptured subclavian or jugular) approach were used in 33.3% patients. In 1 case, after unsuccessful TLE combined approach, migrating lead was extracted with cardio surgery. In patients from Group A, except 45 migrating leads, we extracted 40 leads more, with accessible proximal ending in the PM/ICD pocket, which explains why the venous entry side was also used in this group of patients (Table 3). In the B group, the subclavian approach was used for TLE as standard (84.1%); complex approach was used only in case of technical complications (15.9%; Table 3).

Remarks on technical aspects of migrating lead extraction. Only in 12 among 45 (26.7%) patients, it was possible to use procedure 1. In the remaining 33 (73.3%) we used procedure 2. It is very interesting that the pulling of the extracted lead with the loop liberated first the distal tip of the lead in 12 patients, which means that the PLE was more strongly ingrown in the CVS wall than the distal tip of the lead. It is even stranger if we consider the mean dwell time of migrating leads (more than 10 years). According to our experience

Table 3. Mode of lead extraction and utilized approach.

		Group A	Group B	P
Number of extracted leads		85	1478	
Final approach for extraction of all leads	Simple traction [%]	6/85 [7.1]	181/1478 [0.5]	0.2071
	Subclavian: venous entry side [%]	36/85 [42.3]	1243/1478 [84.1]	< 0.00001
	Femoral [%]	30/85 [35.3]	5/1478 [0.3]	< 0.00001
	Combined [%]	12/85 [14.1]	42/1478 [2.8]	< 0.00001
	Cardiosurgery [%]	1/85 [1.2]	7/1478 [0.5]	0.9187

Table 4. Effectiveness and complications of transvenous lead extraction in the compared groups of patients.

	Group A	Group B	P
No of procedures	45	861	
Full clinical success	43/45 (95.6%)	850/861 (98.7%)	0.2720
Full radiological success	40/45 (88.9%)	816/861 (94.8%)	0.0920
Technical complications	20/45 (44.4%)	136/861 (15.8%)	0.00001
Procedure minor complications	1/45 (2.2%)	15/861 (1.7%)	0.7322
Procedure major complications	0/45 (0.0%)	9/861 (1.0%)	0.9349
Whole procedure duration [min] (SD)	65–370 169.2 (73.1)	30–420 109.5 (46.5)	< 0.00001

the strength of broken PLE adhesion to CVS walls depends on whether there is metal wire sticking out of the polymer insulation, which increases the strength of adhesion. We have not noticed the connection of the phenomenon of PLE strong adhesion either with multiple leads in the superior vena cava, or atrial leads. However, it must be noted that the number of strongly adhering PLE's is still too small for statistical analysis.

We encountered major technical problems during extraction in 6 patients when it was necessary to separate the proximal end using cutting-rotation forces.

Thirty-three patients in whom the PLE was liberated first, the intracardiac tip was liberated by traction of the grasped PLE in 13 subjects, whereas in the remaining 20 patients, it was necessary to separate the tip from the tissue scar in the atrium or the ventricle using extra-long Byrd dilators (9 patients) or obliquely cut sheath of FWS (11 patients).

In the whole group, firm grasping and pulling via a femoral approach resulted in lead extraction in 19 (42%) patients, whereas separation of adhesions, using cutting-rotation forces, was required in 26 (58%) patients with migrating leads. Clinical success rate was very high and similar in both groups (more than 95%, Table 4).

The slightly lower radiological success of TLE without accessible PLEs was a result of 4 lead tips left in the heart wall, and one lead left for cardiac surgery. Technical complications were more frequent in the migrating than in the control group (44.4% vs. 15.8%). It explains prolongation of the procedure by a mean of more than 1 h (Table 4). There were no significant differences in procedural complication between groups.

PLE final location and venous flow. Among patients with migrating leads, there was a high rate of total (26.7%) or partial (37.8%) occlusion of the vein in which the migrating PLEs were primarily located (Fig. 1, Table 5).

Discussion

In the present study of all patients selected for TLE, 45 (5%) subjects had migrating leads. The

Table 5. Condition of venous system in migrating proximal lead end region (vein occlusion degree).

		Normal	Partial occlusion	Total occlusion	P (normal venous vs. occlusion)
Normal venous system		16/45 (35.5%)	0/45 (0.0%)	0/45 (0.0%)	< 0.00001
Vein occlusion	Subclavian vein	0/45 (0.0%)	8/45 (17.8%)	7/45 (15.6%)	
	Anonymous vein	0/45 (0.0%)	6/45 (13.3%)	5/45 (11.1%)	
	Superior vena cava	0/45 (0.0%)	3/45 (6.7%)	0/45 (0.0%)	
Total		16/45 (35.5%)	17/45 (37.8%)	12/45 (26.7%)	

number of patients with such leads varies from investigator to investigator. Bongiorni et al. [4] encountered 73 (3.5%) migrating leads among 2062 leads. Bohm et al. [1] followed up 60 abandoned leads including 5 (8.3%) patients with migrating leads. None of them underwent TLE. In 2 cases with major complications, the leads were extracted surgically, and the remaining 3 patients received anticoagulant or antiaggregation therapy. Despite much more significant technical complications associated with removal of migrating leads, their final effectiveness, at the level of above 88.9%, was comparable to the effectiveness of extracting leads with their proximal ends accessible in the PM/ICD pocket. Bongiorni et al. [4] reported a 100% effectiveness of migrating lead removal in 16 (21.9%) cases as a result of traction via the femoral approach and in the remaining 57 (78.1%) after separation of adhesions via a jugular approach using polypropylene Byrd dilators. In their study, the extracted leads were younger: 69.3 vs. 80.9 months regarding leads with their end accessible in the PM/ICD pocket and 122.2 months for migrating leads in our material. The complication rate in the present study was equally low in both subgroups, that is, 2.2% for migrating leads and 2.7% for the remaining ones. Bongiorni et al. [4] instead of separate complication rates for migrating lead removal via the femoral and jugular approach provided the collective rate of 4.7%. Their paper describes an original modification of transvenous removal of leads accessible in the PM/ICD pocket (156 leads), that is, the leads, which were made to drop in the CVS and then extracted via the jugular approach [4]. These intentionally-made migrating leads had no chance to adhere to the cardiac walls as they were removed immediately. The difference between the migrating leads during surgical manipulation and the leads left in place for some time is the degree of adhesion of the PLE to the CVS wall. In the present study, there were only migrating and ingrown leads. Extraction of migrating leads requires other techniques than of those with their PLE accessible in the PM/ICD pocket. In our study, the removal of migrating leads significantly more often required modification of the approach, being a challenge to the operators. Strength of adherence of PLE to CVS wall is probably a function of time. However, the moment of lead breakage and PLE migration to the CVS is often unnoticed. Case reports confirm the need for adjusting the techniques with modification of instruments used for removal of migrating leads [7–10]. According to our experience the use of other devices (needle eye snare or bioptome) was less effective and was replaced by the techniques presented in the method section.

We noticed that the presence of leads with their proximal ends migrated to the venous system was associated with a high rate of vein occlusion (64%). This was not mentioned in other reports. Female sex predominance in the present study was probably accidental.

Conclusions

1. Migrating non-functional leads with PLE in the CVS were observed in 5% of patients referred for TLE.
2. Removal of migrating leads required other techniques than extraction of leads with their PLE accessible in the PM/ICD pocket.
3. PLEs were strongly ingrown and adherent to the CVS wall in 33 (73.3%) cases of migrating leads.
4. Migrating leads were associated with local venous occlusion.

5. Effectiveness and procedural complication rate for extraction of migrating leads and leads accessible in the PM/ICD pocket were similar.

Conflict of interest: none declared

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